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FLIGHT MEASUREMENTS OF THE AILERON CHARACTERISTICS

OF A GRUMMAN F4F-3 AIRPLANE

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OF A GRUMMAN F4F-3 AIRPLANE

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SUMMARY

The aileron characteristics of a Grumman F4F-3 airplane were determined in flight by means of NACA recording and indicating instruments.

The results show that the ailerons met NACA minimum requirements for satisfactory control throughout a limited speed range. A helix angle of approximately 0.07 radian was produced with flaps down at speeds from 90 to 115 miles per hour indicated airspeed and with flaps up from 115 to 200 miles per hour. With flaps up at 90 miles per hour, the helix angle dropped to 0.055 radian; above 200 miles per hour heavy aileron stick forces seriously restricted maneuverability in roll.

INTRODUCTION

Flight tests to measure the aileron characteristics of a Grumman F4F-3 airplane were made at the request of the Bureau of Aeronautics, Navy Department. The tests were made at Langley Field, Va., during a 2-week period from May 13 to May 27, 1942.

AIRPLANE AND TESTS

The Grumman F4F-3 airplane is a single-place, single-engine, midwing monoplane used as a shipboard fighter (fig. 1). A three-view drawing of the airplane is shown in figure 2, and a cross-sectional outline of the wing and aileron is shown in figure 3. The dimensions in figure 3 were measured from the airplane.

Pertinent dimensions of the airplane are listed below:

Wing area, sq ft . . . . .	260
Wing span, ft . . . . .	38
Wing-taper ratio . . . . .	1.67:1
Aileron chord behind hinge (approx.)	
percent wing chord . . . . .	22.8
Aileron location:	
Inboard end, percent wing semispan . . . . .	65.5
Outboard end, percent wing semispan . . . . .	92.5

Curves showing the variation of aileron angle with control-stick movement are given in figure 4. The gross weight of the airplane as tested was approximately 6680 pounds.

The flight-test procedure was that normally employed at the NACA: From laterally level flight with rudder held fixed at the trimmed position for the speed desired, abrupt aileron was applied and held until maximum rolling velocity was reached. Measurements of aileron position and rolling velocity were recorded by NACA synchronized instruments; stick forces were observed from a force indicator on the control stick; and airspeed was read from the service-air-speed indicator. The aileron-position recorder was installed in the control system at the cockpit; hence, the measured values of aileron angles were those for the ailerons in an unloaded condition. With the ailerons loaded, stretch or give in the system would tend to make the true aileron deflections less than those measured. The stretch in the system was not believed to be appreciable or to give a serious loss in aileron effectiveness.

Measurements were taken at 92, 138, 185, and 230 miles per hour indicated airspeed in level flight (flaps up, gear up, level-flight power) and at 92 and 115 miles per hour in the carrier-approach condition (flaps down, gear down, level-flight power). Additional tests were made with flap and gear up at 288 miles per hour.

#### RESULTS AND DISCUSSION

The results obtained are presented in figures 5 through 10. Figure 5 shows for the carrier-approach condition the variation of  $pb/2V$ , the helix angle in radians described by a wing tip in a roll, and the variation of stick force

with the total change in aileron angle. The total change in aileron angle is the sum of the up- and down-aileron deflections used in the roll as measured from the trim positions of the ailerons. Figures 6 through 9 present similar curves for each of the speeds at which rolls were made with the flaps and gear up. Figure 10 is a summary of the curves of figures 6 through 9.

The criterion for aileron effectiveness is given in reference 1: Rolling velocity obtained by the abrupt use of full aileron should be sufficient to give a minimum helix angle  $pb/2V$  of 0.07 radian at all speeds up to 80 percent of the maximum level-flight speed without exceeding a stick force of 30 pounds. On this basis the results may be discussed and summarized as follows:

1. With flaps down, a total aileron deflection (maximum) of  $33.3^\circ$  produced values of  $pb/2V$  of 0.068 radian at 92 miles per hour indicated airspeed and 0.08 radian at 115 miles per hour indicated airspeed.
2. At 92 miles per hour indicated airspeed, flaps up, the values of  $pb/2V$  obtained were 0.054 radian and 0.056 radian, values substantially below 0.07.
3. A value of  $pb/2V$  of 0.07 radian was obtained at 138 and 185 miles per hour indicated airspeed; however, a stick force greater than 30 pounds was required at the second speed.
4. At 230 miles per hour indicated airspeed, the value of  $pb/2V$  dropped to 0.066 radian and rolls made with full aileron deflection required excessively high stick forces.
5. The variation of  $pb/2V$  with change in total aileron angle becomes nonlinear at large aileron deflections. The fact that this tendency increases only slightly with speed indicates very little loss in effectiveness due to cable stretch.

In order to show the aileron control available with a stick force of 30 pounds, figure 11 was constructed using the data of figure 10. It will be noted that a  $pb/2V$  value of 0.07 was obtainable only for a speed range from approximately 120 to 160 miles per hour. The maximum rolling velocity obtainable at 10,000 feet altitude was  $58^\circ$  per second at a speed of 190 miles per hour.

Figure 12 compares the aileron effectiveness of the Grumman F4F-3 with that of the Curtiss P-40 on a basis of rolling velocity obtainable at 10,000 feet with a 30-pound stick force. The ailerons on the P-40 airplane are considered to be satisfactorily light and effective. It will be seen that the ailerons on the F4F-3 do not approach the performance obtained from those on the P-40.

In conclusion it may be said that the F4F-3 ailerons met NACA minimum control requirements for a limited speed range but lost effectiveness with flaps up at low speeds and were too heavy for satisfactory maneuverability at high speeds.

Langley Memorial Aeronautical Laboratory,  
National Advisory Committee for Aeronautics,  
Langley Field, Va.

#### REFERENCE

1. Gilruth, R. R.: Requirements for Satisfactory Flying Qualities of Airplanes. NACA A.C.R., April 1941.

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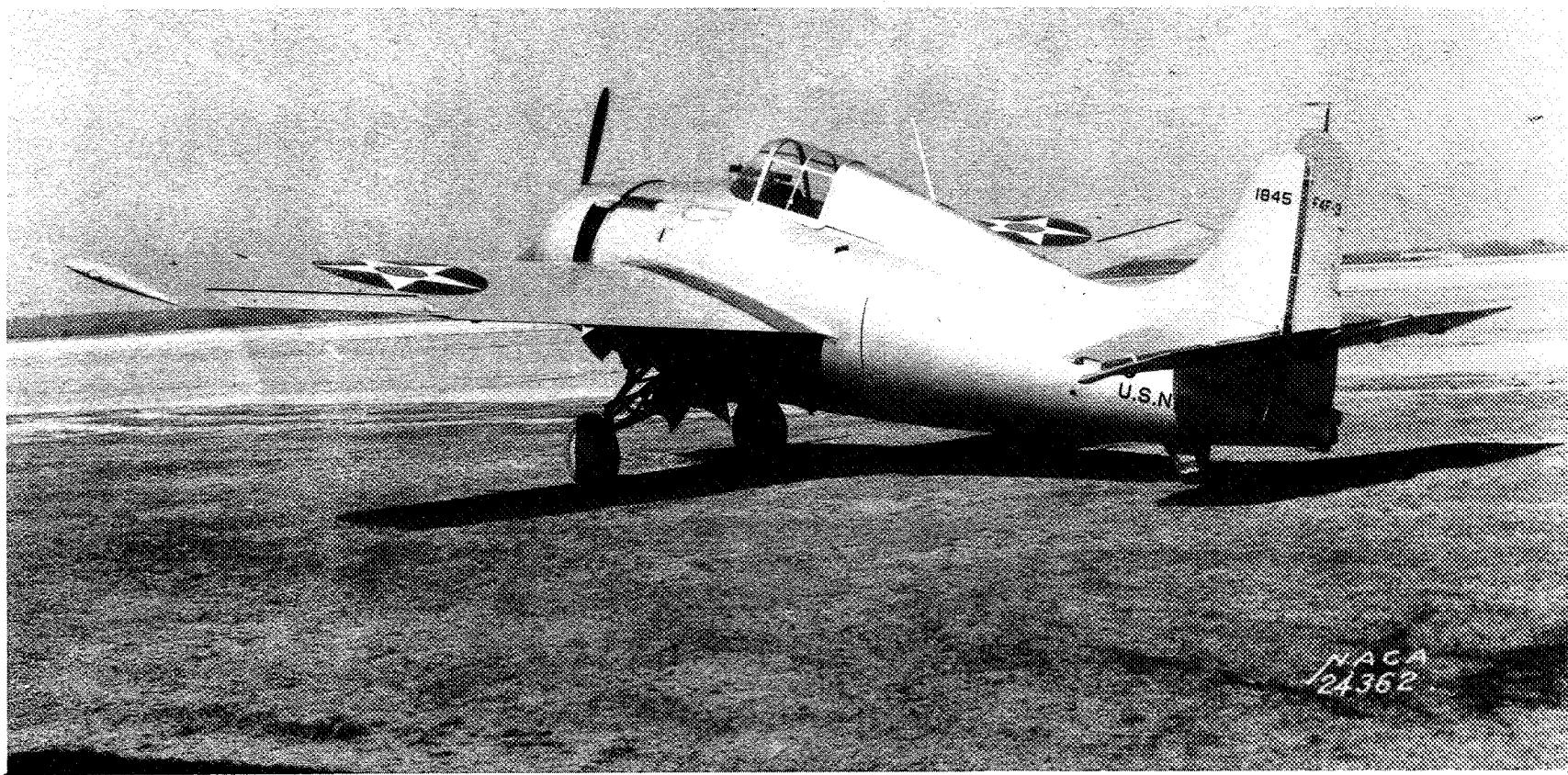


FIGURE 1. - THREE-QUARTER-REAR VIEW OF GRUMMAN F4F-3 AIRPLANE.

FIG. 1

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Stagger G"

Fig. 2

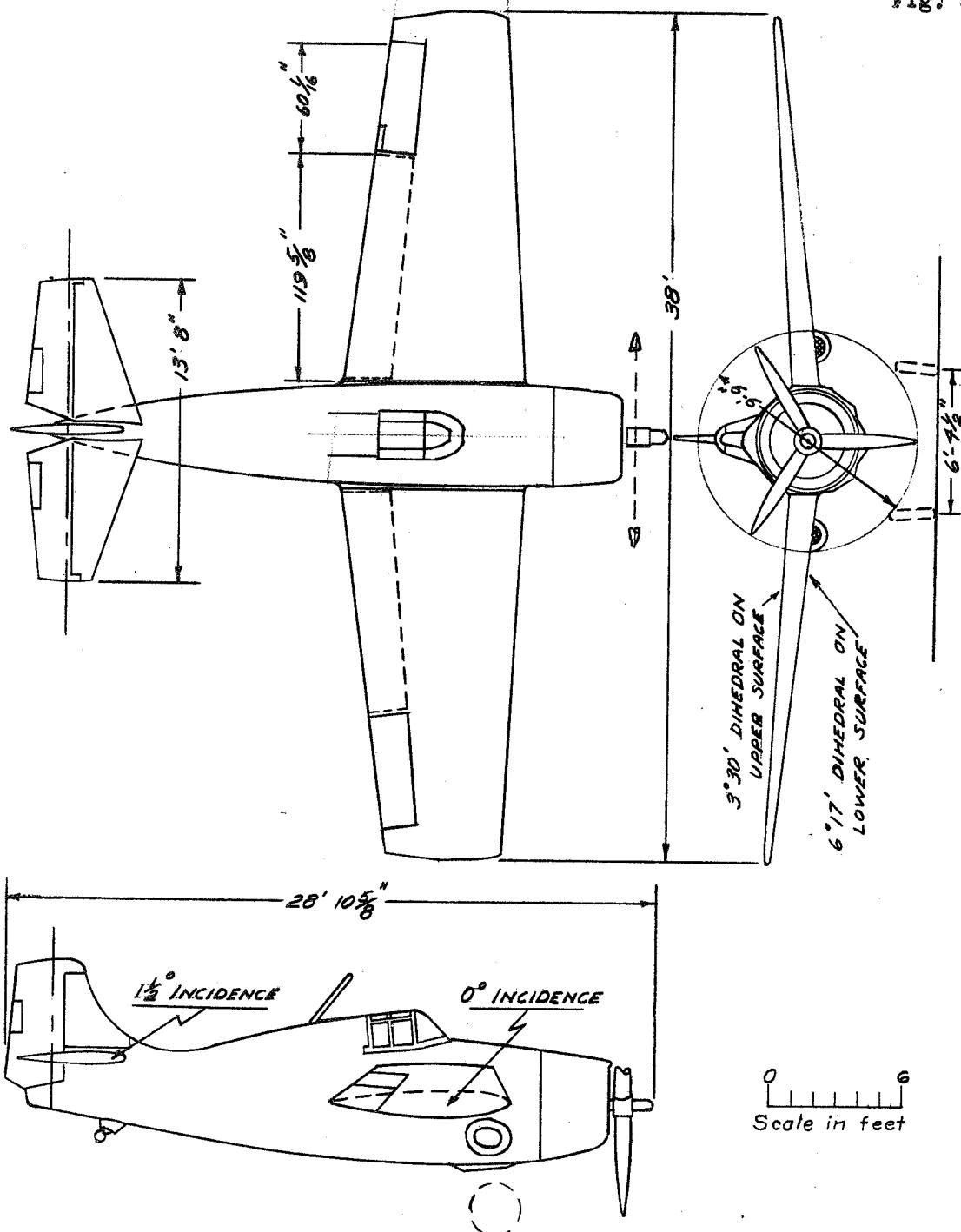


Figure 2. - Three-view drawing of the Grumman F4F-3 airplane.

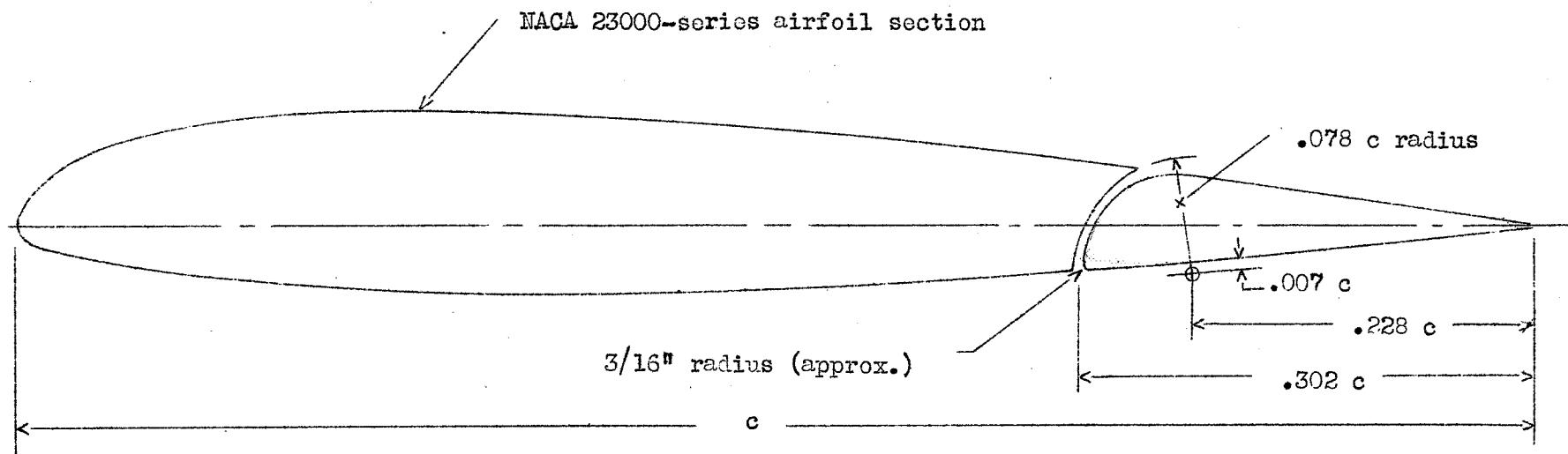


Figure 3.- Cross-sectional outline of wing and aileron.  
Grunman F4F-3 airplane.

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Fig. 4

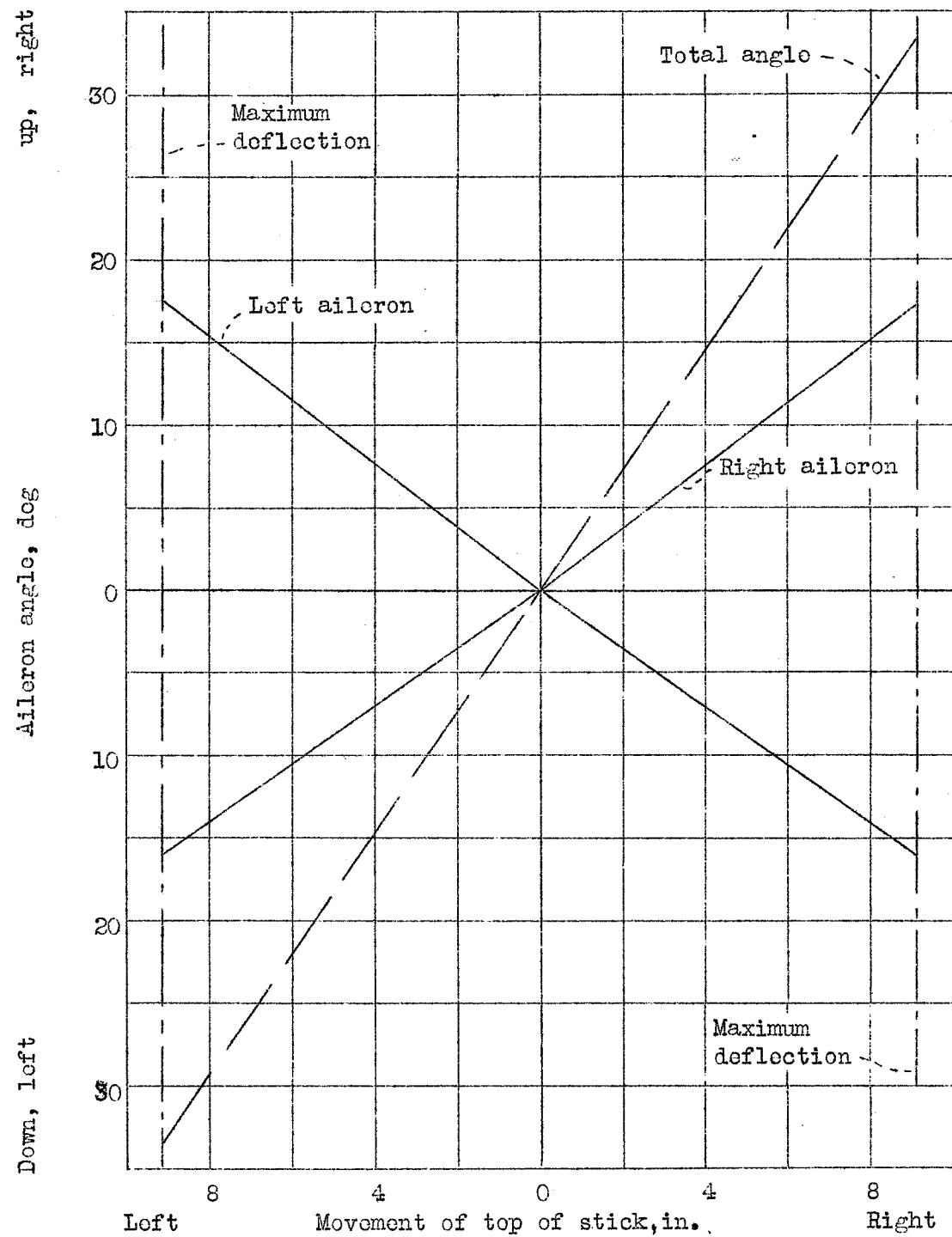


Figure 4.- Variation of aileron angle with control-stick movement. Grumman F4F-3 airplane.

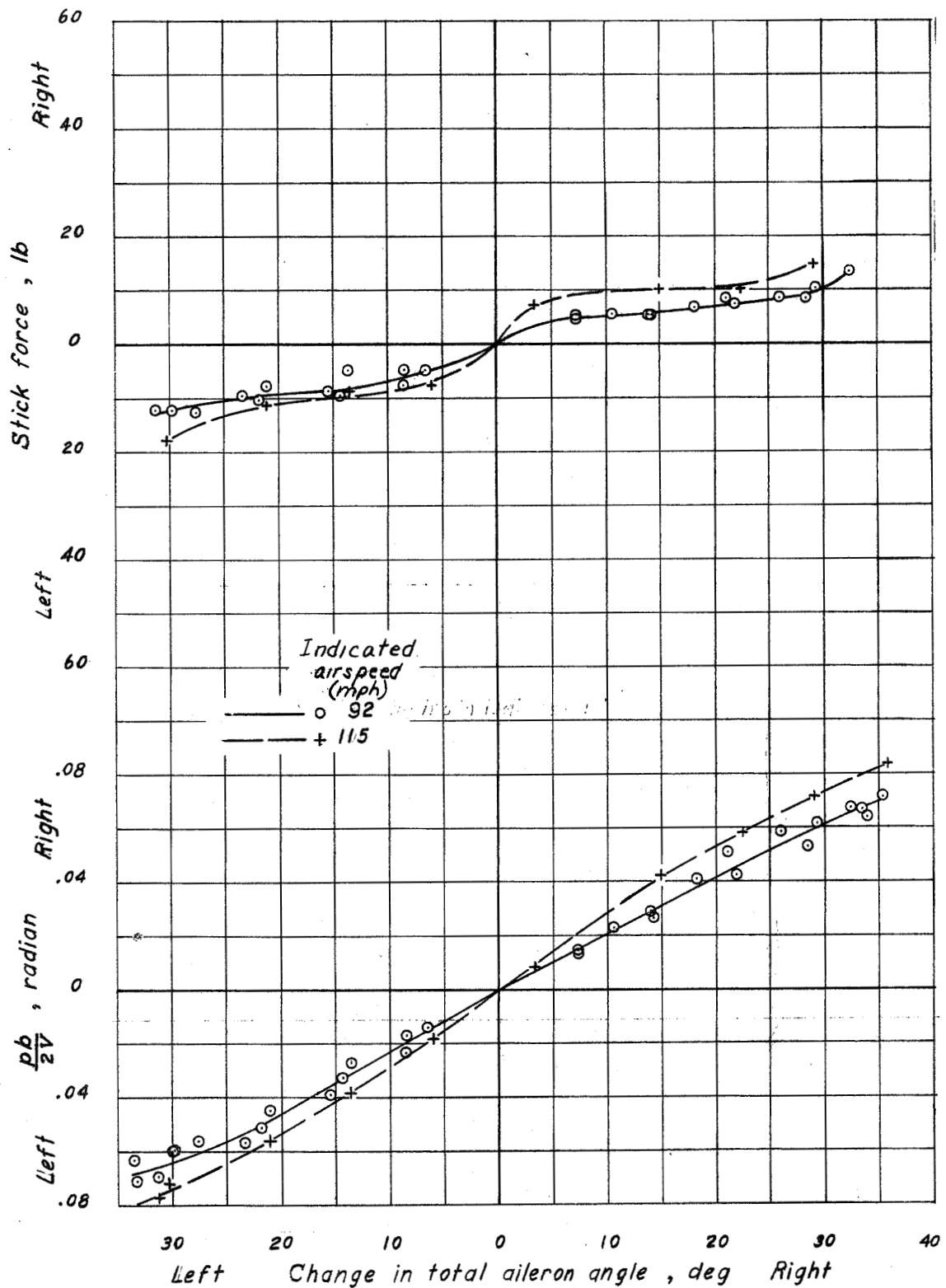


Figure 5.- Variation of aileron stick force and  $\frac{pb}{2V}$  with total aileron deflection in the carrier-approach condition (flaps down, gear down, level-flight power) at 92 and 115 miles per hour indicated airspeed. Grumman F4F-3 airplane.

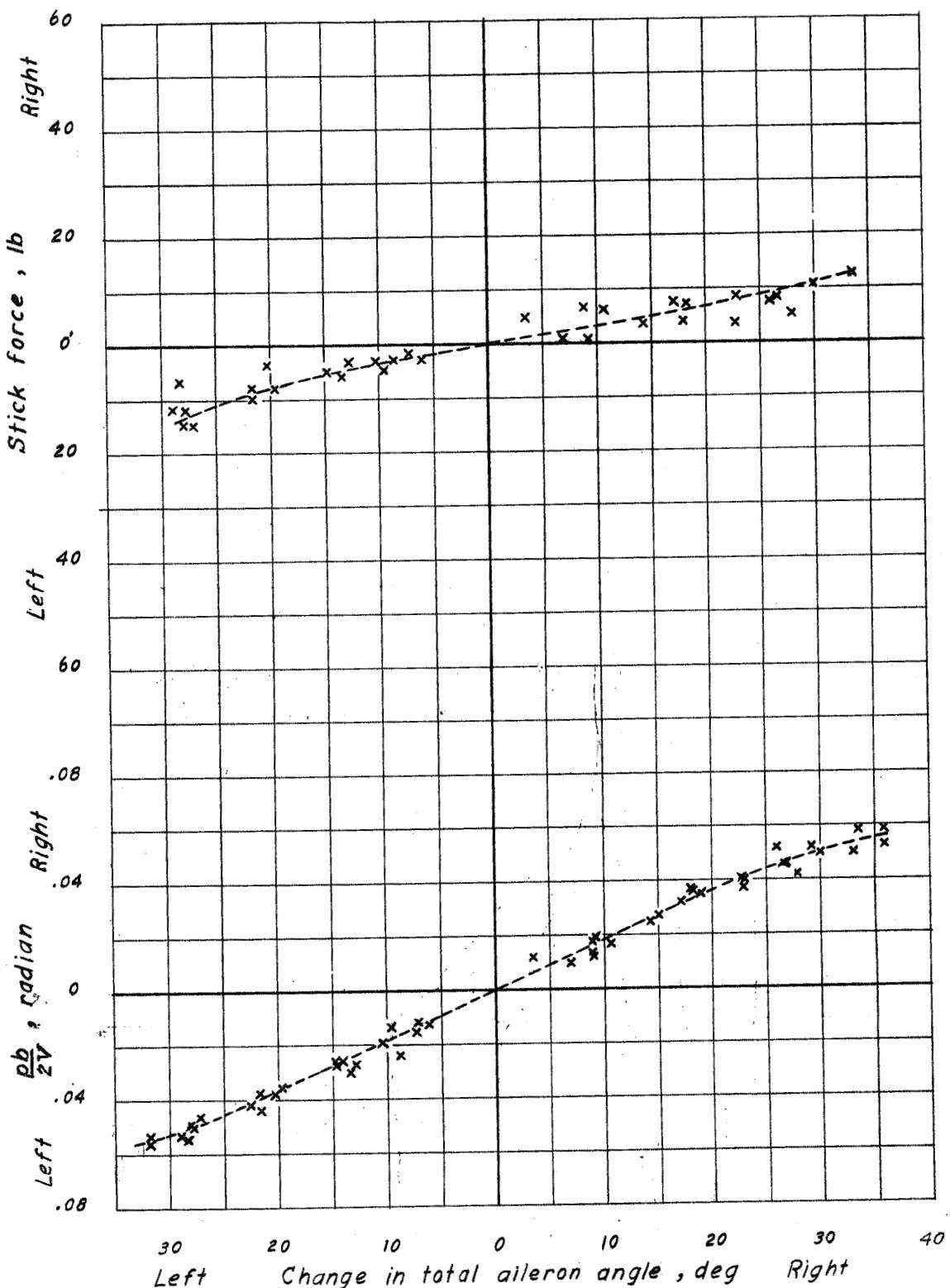


Figure 6. - Variation of aileron stick force and  $\frac{pb}{2V}$  with total aileron deflection in level flight (flaps up, gear up, level-flight power) at 92 miles per hour indicated airspeed. Grumman F4F-3 airplane.

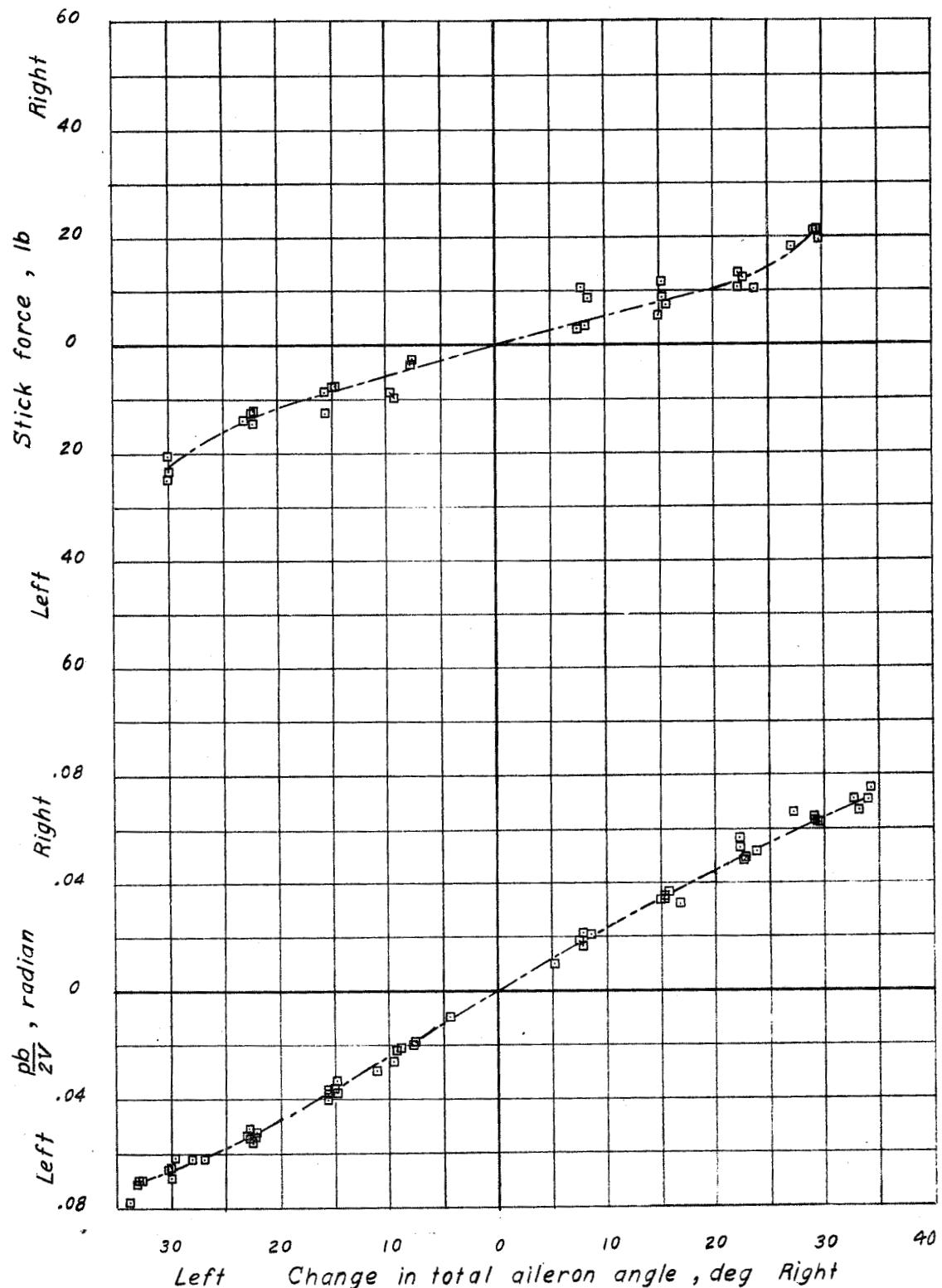


Figure 7. - Variation of aileron stick force and  $pb/2V$  with total aileron deflection in level flight (flaps up, gear up, level-flight power) at 138 miles per hour indicated airspeed. Grumman F4F-3 airplane.

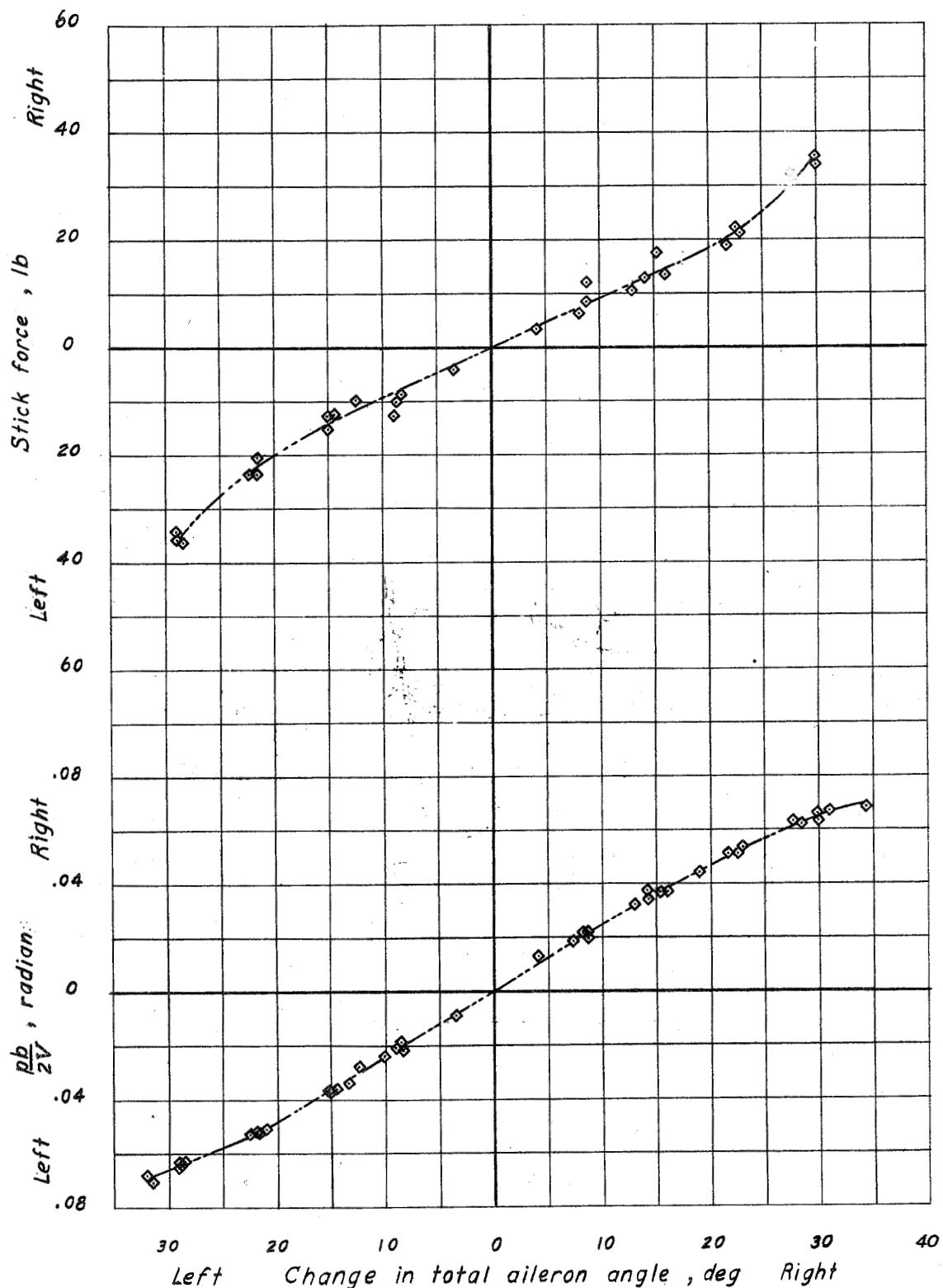


Figure 8. - Variation of aileron stick force and  $pb/2V$  with total aileron deflection in level flight (flaps up, gear up, level-flight power) at 185-miles-per-hour indicated airspeed. Grumman F4F-3 airplane.

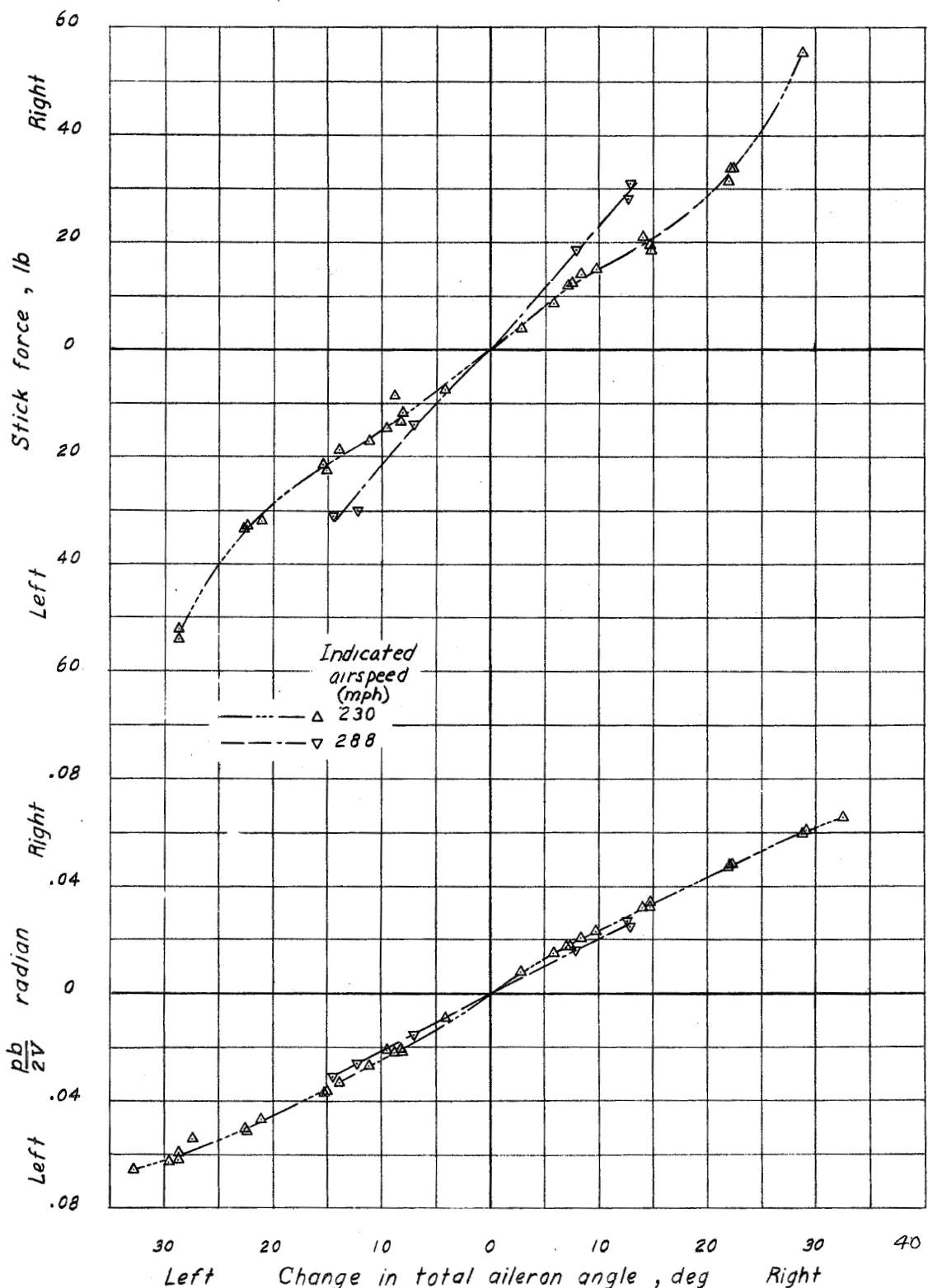


Figure 9. - Variation of aileron stick force and  $pb/2V$  with total aileron deflection (flaps up, gear up, power on) at 230 and 288 miles per hour indicated airspeed. Grumman F4F-3 airplane.

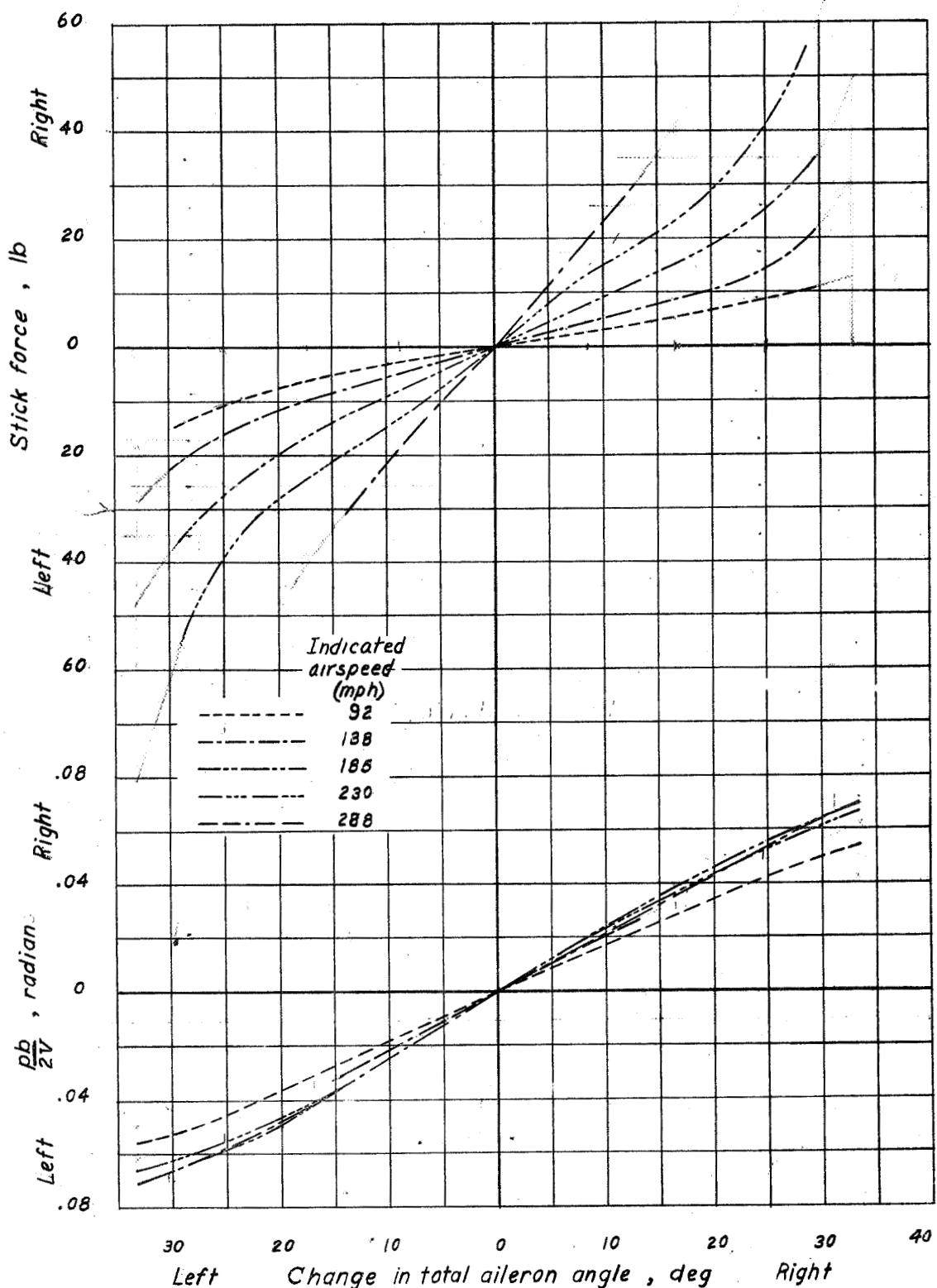


Figure 10. - Variation of aileron stick force and  $\frac{pb}{2V}$  with total aileron deflection at 92, 138, 185, 230, and 288 miles per hour indicated airspeed (flaps up, gear up, power on). Grumman F4F-3 airplane.

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Fig. 11

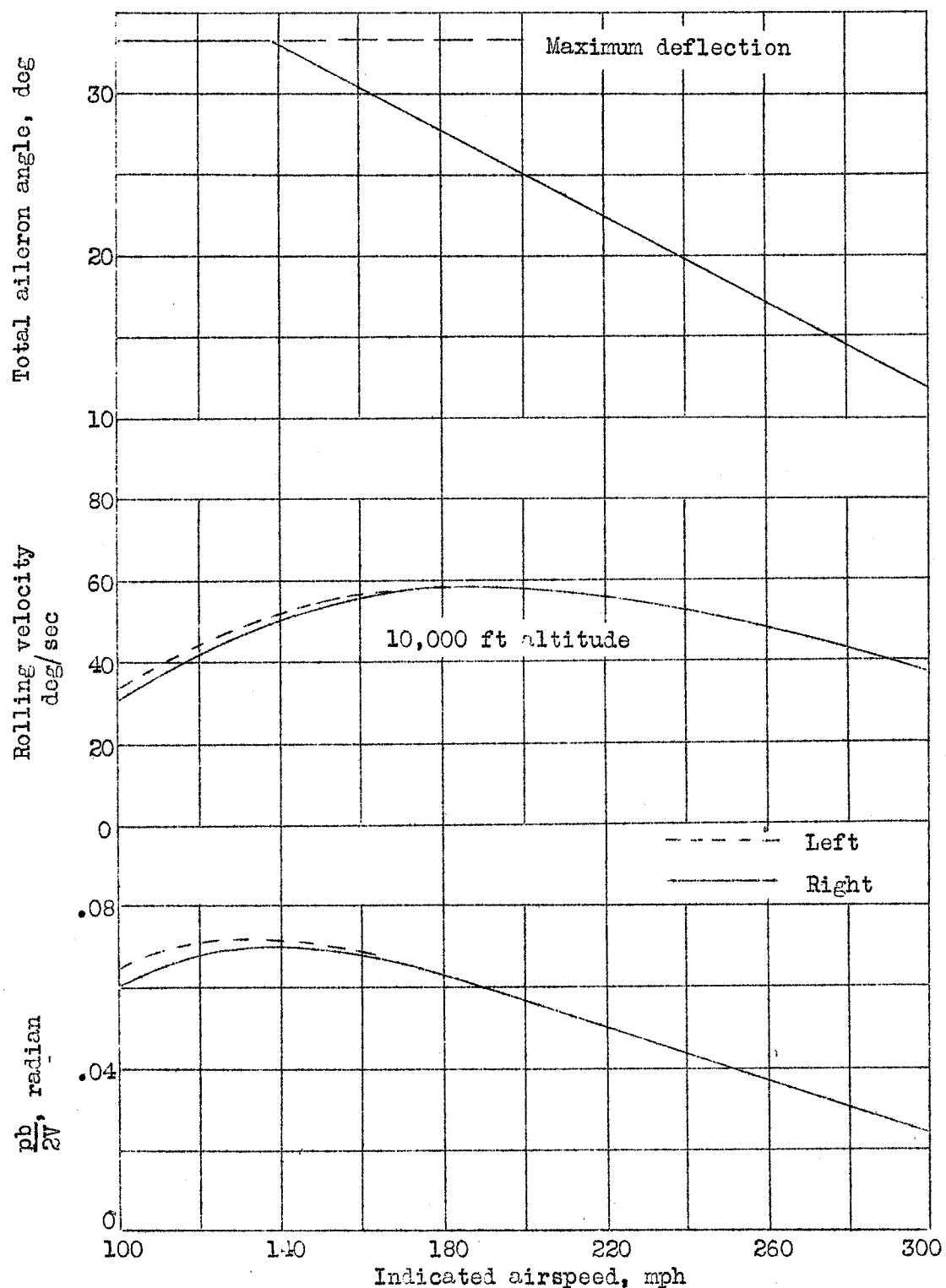


Figure 11.— Aileron characteristics with stick forces limited to 30 pounds. Flaps up, gear up, power on. Grumman F4F-3 airplane.

Rolling velocity at 10,000 ft

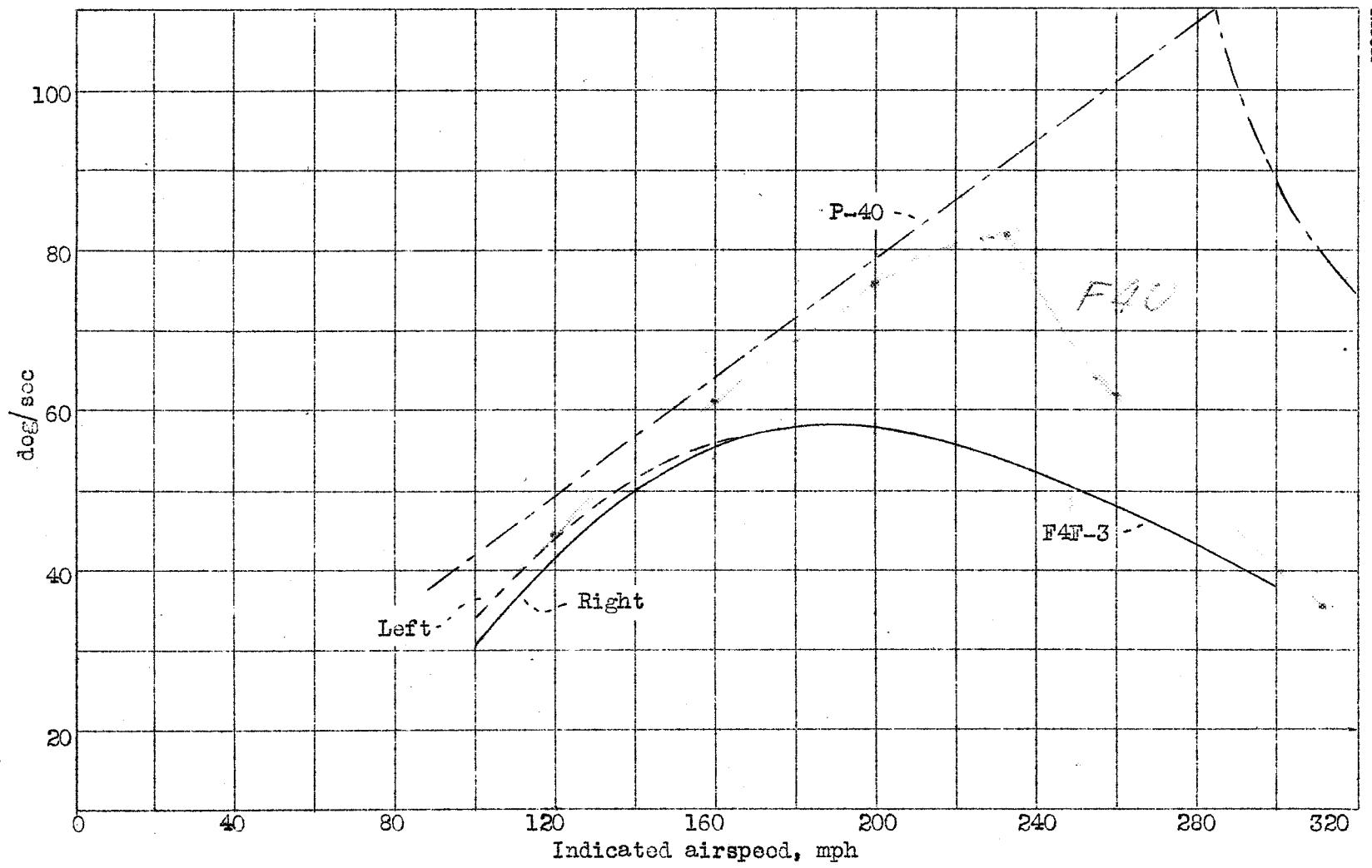


Figure 12.- Rolling velocities obtained at 10,000 feet altitude with a stick force of 30 pounds. Grumman F4F-3 and Curtiss P-40 airplanos.

Fig. 12

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